IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 14, Issue 3 Ver. VI. (May - June 2017), PP 46-52
www.iosrjournals.org

Design and Execution of Fixture to Perform Slitting Operation On Feed Gear Shift Fork Component In Fn2 Milling Machine

Uddandapu Pradeep Kumar[1], P.Sreenivas[2], S.Mallikarjuna Reddy[3]
[1]*(Asst Professor,Mechanical Engineering Department,K.S.R.M Engineering college,JntuA university,A.P, India)*
[2]*(Asst Professor,Mechanical Engineering Department, K.S.R.M Engineering College JntuA university,A.P,India)*
[3]*(Asst Professor,Mechanical Engineering Department, K.S.R.M Engineering College, JntuA university,A.P, India)*

Abstract: *Design and execution of fixture to perform slitting operation on feed gear shift fork component in FN2 milling machine task is to design fixture for the component Feed gear fork used in radial drilling machines for gear engaging purpose. The report begins with the description of classification of fixture. This is followed by detail description of various components employed in the designing of the fixture. Details of the machine used have been provided, supplemented by diagram. It include information about the various products manufactured and also the various branches working in India. Relevant part diagrams have been included apart from the machine photograph. The criteria for this design prove are accuracy, positive locations, repeatability, production rate, and importantly the reliability under the action of the fatigue forces experienced. The clamping constructions have also been accounted for the proposed design. The proposed designs were then checked for safety under the action of the involved stresses. The calculation of the cutting forces has been showed and proved that the forces at various vital points in the design are well below the safety limits.*
Keywords: *Design,fixtures ,base plate,Catia V5 R16,Modelling,FN2 milling Machine (10 Italic)*

I. Introduction

In this chapter basic concepts of fixtures are briefly discussed and problem for present work is defined.

1.1 Fixtures

Definition of Fixtures:
A fixture may be defined as a device that holds and locates a work piece. The fixture does not guide the tool.

1.2 Types of fixtures

- Milling Fixture
- Lathe and turret lathe fixture
- Boring fixture
- Tapping fixture
- Turning fixture
- Welding fixture
- Assembly fixture

1.3 Materials used in fixtures

Fixtures are made of variety of materials some are hardened to resist wear. It is sometimes necessary to use on ferrous metals like phosphor, bronze to reduce wear of matting or use of nylon or fibers to prevent damage to work pieces some of the materials, which are used in fixture.
Mild steel: is issued for the most of the parts in the fixtures. Mild steel contains less than 0.25% of carbon and the content of manganese varies from 0.1% to 0.8% these steels can also be case hardened.
Cast Iron: It is used for odd shapes to save machining and laborious fabrication. By casting the cast iron with stands vibration hence is used for bases and bodies of milling fixture.

Nylon and fiber: These are used for soft lining for clamps to prevent damage of the work piece due to clamping pressure. Nylon or fiber pads are screwed or stuck to mild steel clamps.The fixtures are economical means to produce repetitive type of work by incorporating special work holding and tool guiding devices.

The following are the advantages of fixtures in mass production work.

- It eliminates the marking out, measuring, and other setting methods before machining.
- It increases the machining accuracy, because the work piece is automatically located and the tool is guided without making any manual adjustment.

- It enables production of identical parts, which are interchangeable. This facilitates the assembly operation.
- It increases the production capacity by enabling a number of work pieces to be machined in the single setup, and in some cases a number of tools may be made to operate simultaneously.
- It reduces the operator's labour and consequent fatigue as the handling operations are minimized and simplified.
- It reaches semi-skilled operator to perform the operations as the setting operations of the tool and the works are mechanized. This saves labour cost.
- It reduces the expenditure on the quality control of the finished products.
- It reduces the overall cost of machining by fully or partly automating the processes.

Elements of fixtures
BASE PLATE
It absorbs forces arising due to vibration effect and chatter. It is usually made of mild steel plate.
Clamping Devices :A fixture may have one or more clamping devices to clamp the work piece rigidly against all disturbing forces. Some of the clamping devices used are strap clamp, screw clamp, hinged clamp, c-clamp, edge clamp, groove clamp etc
Location and positioning of Elements
The excessive thrust of the cutter must be resisted by a fixer stop because clamping device alone may not be sufficient to accomplish it.
Locating System
The locating system is used be in conjunction with the clamping system to completely constraining the work piece or eliminate as many of the six degree of freedom as are necessary for the operations to be completed with the required accuracy.
Types of Location
- Cylindrical location
- Six point location

Design Consideration Of Fixture
The following 'are the major factors to be considered by the designer while designing a fixture.
- The quality of the part to be produced.
- The quantity of the part to be produced.
- The machine required for the operation.
- Safety of the operator.
- Weight of material.
- Cost of the project.

Before design the fixture the designer should study the work piece thoroughly and he should design a fixture for the type of work with all facilities. Considering deeply the design of the fixture the designer should:
- Select proper clamping arrangements.
- Select proper indexing devices.
- Study the rigidity and vibration problem.
- Select proper table fixing arrangements.
- Study proper methods of manufacturing the fixture base, body and other components.
- Retrieval of the components from the fixture.

II. Machine Specifications

2.1 Specification of FN2 milling machine

Table	Horizontal	Universal	Vertical
Over all dimension (length*width) mm		1350*310	
Clamping area (length*width) mm		1520*310	
. Number and width of T slots mm		3-16	
Centre distance between T slots mm		65	
Power operated longitudinal traverse mm		800	
Power operated cross traverse mm		265	
Power operated vertical traverse mm		400	
Minimum distance left hand end to centre of milling spindle mm		250	
Swivel of table to either side degrees		45	
Maximum safe weight on table kg	350	250	350

Milling spindle	Horizontal	Universal	Vertical
Number of speeds		18	

Speed range rpm		35.5-1000	
Diameter of front bearing mm		85.725	
Spindle nose : 1) standard ISO 2) upon request ISO		40 50	
Swivel of milling head to either side degrees			45
Vertical quill movement			70

Feeds	Horizontal	Universal	Vertical
Number of feeds		**18**	
Feed range: (1) longitudinal and Cross mm/min (2) vertical mm/min		16-800 4-200	

Rapid rate (1) Longitudinal and cross mm/min 2)Vertical		3200 800	

Power	Horizontal universal	Vertical
main motar kw/rpm	5.5/1500	
Feed motar kw/rpm	1.5/1500	

Space Required	Horizantal	universal	Vertical
Length * Width * Heigth	257*220*207	257*284*207	257*192*197

Weigth	Horizantal	Universal	vertical
Net/gross approx kg	2400/3200	2500/3300	2500/3350

2.2 Descriptions:

Stream lined construction, rugged and vibration free -5.5kw motar for heavy stock removal –power operated feeds and rapid traverse in all directions – independent feed drive motar –wide range of spindle speeds and feeds upto 1800 rpm and feeds-up to 800 mm/min-all operations controlled with effortless ease by pushing buttons-inching push button for speed and feed drives

III. Design Analysis

3.1 Calculations of loads

(1) Weight of collets:

Material used: Spring Steel

Weigth of each collet =260gm

Weight of two collets =260*2 =520gms

=0.52 kgs

=0.52*9.81=5.1012N

2) weight of locking Nuts:

(Assuming Materials used as C-45)

Weight Volume = Specific weight* Volume

Where volume = Area * Length (or) Height

$=\pi/4*8*(30^2- 20^2)=3141.5926\ mm^3$

$= 3.146*10^6\ m^3$

Specific weigth of C-45 material $=78400\ N/m^3$

Weight of locking nut $= 78400* 3.1416 *10^6$

=0.2463N

Weigth of 2 locking nuts =0.2463*2 =0.4926N

(3)Weight of Eccentric shaft bushes:

Volume =Area * Height $=\pi/4(20^2-14^2)*20 =304.4245mm^3$

Specific weight of C-45 $=78400N/m^3$

Weight of eccentric ring = specific weight * volume

$= 78400*3.2044* 10^{-6}$

= 0.2512 N

Weight of two Eccentric shaft bushes = 0.2512*2

= 0.5024 N

Specific weight of C-45 =78400N/m^3
Volume =Area * Height =$\pi/4(20^2-14^2)*20$ =304.4245mm^3

4) Weight of Eccentric rings

Volume = $(\pi/4*10^2*10) + (\pi/4*(22^2-16^2)*18)$
= 4008.6722mm^3
= $4.0087*10^{-6}$ m^3
Specific weight of C-45 Material =78400 N/m^3
Weight of Eccentric ring = Specific weight * volume
= $78400*4.0087*10^{-6}$
= 0.3143 N
Weight of two Eccentric = 0.3143*2
Rings = 0.6286 N

5.Weigth of Lever Handle

Volume = $\pi/4*(22^2-16^2)*15) + (\pi/4*15^2*70)$
= $(4/3*\pi*6^2)$
= 15206.8792 mm^3
= $1.5207*10^{-5}$ m^3
Weight of lever handle = 78400 N/m^3

6. Weigth of distance rings

Volume = $\pi/4*(30^2-20^2)*16$
= 6283.1853 mm'
= $6.2832*10^{-6}m^3$
Specific weight of C-45
Material = 78400 N/m^3
Weight of distance = Specific weight * volume
Ring = $78400*6.28328*10^{-6}$
= 0.4926 N
Weight of two distance = 0.4926*2
Ring = 0.9852 N

7)Weight of eccentric lock nuts

Volume = $\pi/4*(20^2-10^2)*6$
= 1413.7167 mm^3
= $1.4137*10^{-6}m^3$
Specific weight of C-45 = 78400 N/m^3 material
Weight of Eccentric lock nut = Specific weight* Volume=$78400*1.4137*10^{-6}$
= 0.1108 N
Weight of two Eccentric lock = 0.1108*2
Nuts = 0.2217 N

8) Weight of fixture side plates

Volume = $(l*b*t) - (\pi/4*D^2*h)$
= $(75*70*20) - (\pi/4*25^2*20)$
= 95182.5229 mm^3
= $9.5182*10^{-5}m^3$
Specific Weight of C-45 = 78400 N/m^3
Material
Weight of side plate = specific weight * volume
= $78400*9.5182*10^{-5}$ m^3
= 7.4623 N
Weight of two fixture side = 7.4623*2
Plates
= 14.9246 N

9) Weight of fixture plate (where component is placed)

Volume = $(280*75*20) - (\pi/4*35^2*20)-(2*(\pi/4*18^2*20)$
= $390578.9848\ mm^3$
= $3.9058*10^{-4}\ m^3$

Specific Weight of C-45 Material = $78400\ N/m^3$

Weight of fixture plate = specific weight*volume
= $78400*3.9058*10^{-4}$
= 30.6215 N

10)weight of boss

Volume = $(\pi/4*55^2*10) + (\pi/4*35^2*40) - (55*10*4) -(35*20*4)$
= $57242.8044\ mm^3$
= $5.7243*10^{-5} m^3$

Specific Weight of C-45 Material = $78400\ N/m^3$

Weight of boss = specific weight*volume
= $78400*5.7243*10^{-5}$
= 4.4878 N

11)Weight of eccentric shaft

Volume = $(\pi/4*14^2*245)+(\pi/4*16^2*60)$
= $49778.5356\ mm^3$
= $4.9778*10^{-5} m^3$

Specific weight of C-45 Material = $78400 N/m^3$

Weight of eccentric shaft = specific weight * volume
= $78400*4.9778*10^{-5}$
= 3.9026N

Total weight = 5.1012+ 0.4926+ 0.5024+ 0.6286+ 1.1922+ 0.9852+ 0.2217+ 14.9246+ 30.6215+4.4878+3.9026
= 63.0604 N
= 6.428 kgs

But we consider the working load as 20 kg

To calculate the load acting on the base plate

We have , F = W * g
= 20*9.81
= $196.2 \approx 200$ N

3.2 Design of Base plate

Assumptions for base plate:

(a) Design for static load.
(b) Design for dynamic load,

(a) Static load

Working load = factor of safety * static load
= 3.0*200
= 600N

Working load = 0.6 KN

Since the load tends to compress the component, therefore compressive stress is developed.

$\sigma_{(S)} = \sigma_{(yield)/F.O.S}$
= 353/3 (for C-45 : σ_y= 353 Mpa)
= $117.667 \approx 118$ Mpa (or) 118 N/mm^2

Stress induced in base plate

Stress on base plate = total weight acting on the base plate / area of the base plate

$$= \frac{\text{weight of component + weight of fixture parts on base plate}}{\text{Area of the base plate}}$$

= (14.715 + 63.0604) / (75*35*2)
= $14.814*10^{-3}\ N/mm^2$

Since the stress induced in the base plate is less than the allowable stress,hence the design of the base plate is safe

Dynamic load (or) Forces

Dynamic forces are due to the cutting forces on the component

Cutting speed, v=πDN/1000 m/min

The dynamic forces will be maximum in case of milling operation,as the metal removel rate is maximum in milling.

Milling cutter diameter D= 150 mm

Cutter speed N= 40 rpm

Cutting speed v= πDN/1000

= (π*150*40)/1000

=18.85m/min

Cutting Force, F= 10HP/18.85

=0.5336 N

F(working)= Factor of safety * cutting force

=3*0.5336

=1.6008N

Due to this load bending,stresses are developed in the base plate.

Bending stress σ_b =M/Z

Now considering the dimensions obtained from static load , bending stresses are calculated.

Where M= bending moment= 1.6008 N

Section modulus ,$Z=(b*h^2)/6 = (75*208^2)/6 = 540800 mm^3$

Bending stress, $\sigma_{(b)} = M/Z = 1.6008/540800 = 2.96*10^{-6}$ N/mm^2

Since the stress obtained ,i.e. $2.96*10^{-6}$ N/mm^2 is less compared to permissible stress 118 N/mm^2

Hence the design is safe.

IV. Cost Analysis

Machine hour rate =(Investment on machine cost+ Interest rate +cost of average standard tools +cost of average maintenance +Incentive cost + energy (electricity charges)+ remaining overhead charges)

Machine hour rate of FN2 milling machine =150 Rs/hr.

4.1 Cost of slitting operation of component (Existing method)

On FN2 milling machine:

Machining time =12min =0.2hr

Total cost of machining =0.2* 150 = Rs 30 Per component.

Standard setting time for shift quantity (20 no's per shift)

In FN2 milling Machine =45 min/batch =0.75 hr/shift

=0.75*Rs.150 =Rs.112.5 Per shift

Set up cost =Rs.5.625/component

Total cost per component =Machining cost +setup cost =30+5.625 =Rs.35.625/component

For 1000 components =Rs.35,625/-

4.2 Cost of slitting operation of component (New method).

Machine hour rate =150 Rs/hr.

Machining time =6 min=0.1 hr

Total cost of machining = 0.1*150 = Rs 15 Per component

Standard setting time for shift quantity (20 No's)

Setup cost =Rs.5.625/component.

Total cost per component = machining cost + setup cost

=15+5.625= Rs.20.625/component

For 1000 components =20.625 *1000= Rs.20,625/-

Net saving= cost for existing method –cost for New method

=35,625-20625

=Rs. 15,000/- for 1000components

Net saving =Rs.15 Per component

V. Production Analysis

5.1 Number of components machined(Existing Method)

On FN2 milling machine:

Setting time =45 min/batch

Machining time =12min/ component

Total machining time =45+12*X
X-Number of components machnined
The Total number of components machined per shift
Total Machining time =6hr
= 360 min
360=45+12*X
X= (360-45)/12 =315/12 =26.25 =26
26 components can be machined by the existing method

5.2 Number of components machined (NEW METHOD)
On FN milling machine
Setting Time =45min
Machining time =6min
Total machining time =45+6 = 51 min per component
Therefore the number of components machined per shift: Per shift, total maching time =45+6*X
Where x is number of components machined
360= 45+6*X
X=(360-45)/6
X=315/6
X=52.5=53
53 components can be machined by the new method
By New method (27) more number of components can be machined per shift.

VI. Conclusion

The Deficiencies noted in the existing process of manufacturing feed gear shift fork component can be overcome by the designing and executing the rigid fixture.
Use of fixture which was designing and executed has got following advantages over earlier jobbing method
- By the design and manufacture of fixture the operation time is reduced
- Instead of skilled labourers,semiskilled laborers can be employed
- Since the positioning accuracy is pre-determined the inter changeability is easy
- Loading and unloading of the components is feasible
- Operators fatigue life is less because easy handling of the part
- Consistency in the product quality
- Ideal cycle time is reduced
- Productivity increases and hence profitability

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